

Last Name: _____ First Name: _____

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MAE 2381: EXPERIMENTAL METHODS AND MEASUREMENTS

Spring 2007

MIDTERM EXAMINATION

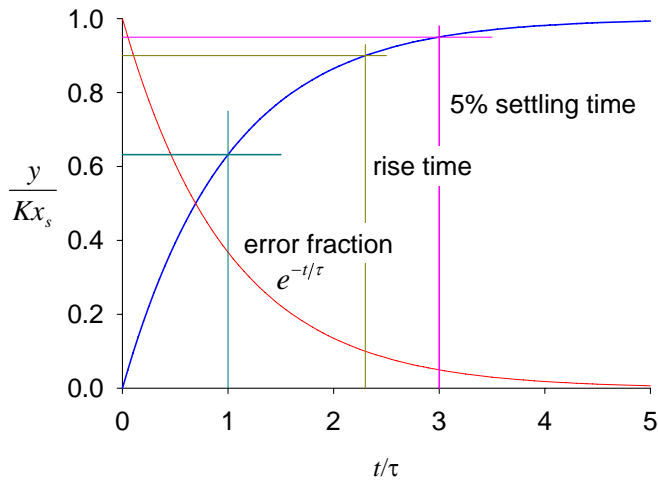
April 4, 2007

ANSWERS

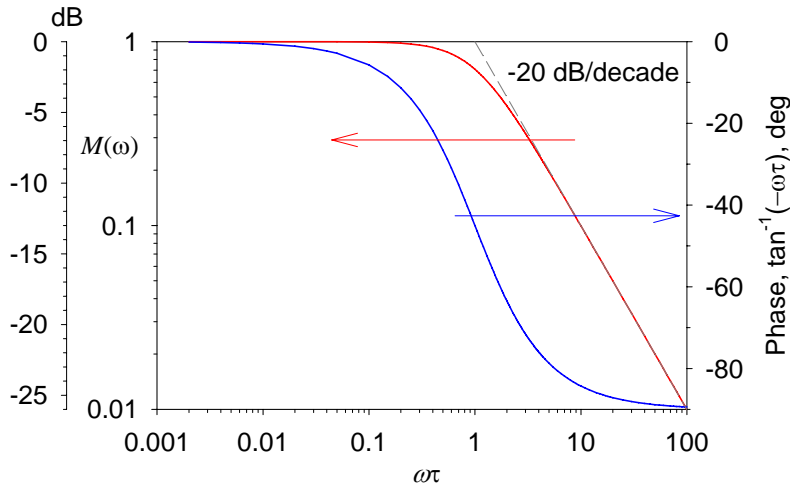
INSTRUCTIONS

- This is a closed-book/closed-notes examination. All formulas, constants and fluid properties will be given to you.
- This quiz is conducted in accordance with University rules regarding academic honesty.
- There is only one correct answer per question/problem. Two points for each correct answer. The total score is **50**.
- You have **FIFTY MINUTES**.
- This booklet consists of eight (8) pages.

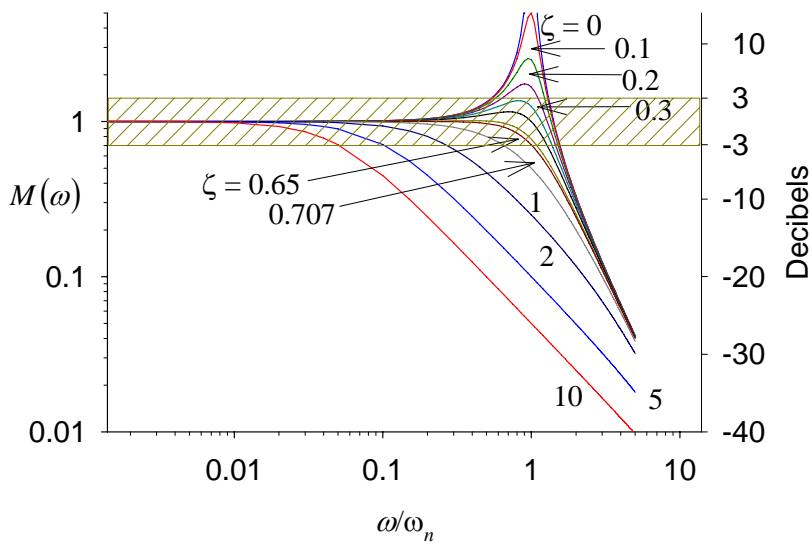
INSTRUCTOR



Response of 1st order system to a step excitation



Frequency response of 1st order system



Frequency response of 2nd order system

For each problem, mark the correct answer or most appropriate in the corresponding box

1. Which one of the following statements is **NOT** true regarding least squares regressions

- a. It is a numerical technique that may have no physical basis
- b. It requires minimization of the sum of the squares of the deviations between the regression and actual data
- c. The correlation coefficient should be as close to one as possible
- d. The technique works best for linear (straight line) fits
- e. One of the applications of least squares regressions is to obtain explicit algebraic expressions for the data

a	b	c	d	e

2. Only one of these is an **APPROPRIATE** statement regarding the hardware required for data acquisition

- a. Sensing, wiring, noise reduction, digitizing, transmission, presentation, and storage and playback
- b. Sensing, conversion, manipulation, transmission, presentation, and storage and playback
- c. Calibration, conversion, filtering, digitizing, transmission, presentation, and storage and playback
- d. Sensing, multiplexing, conversion, transmission, presentation, and storage and feedback
- e. None of the above

a	b	c	d	e

3. One of the following statements is **NOT** true regarding an instrument's accuracy:

- a. An accurate instrument is one that is also precise at the same time
- b. An accurate instrument is one whose performance can be traced to a secondary standard
- c. An accurate instrument should exhibit a minimum amount of hysteresis
- d. An accurate instrument has a calibration sheet when purchased
- e. An accurate instrument is one which will not drift significantly with changes in daily temperature

a	b	c	d	e

4. A 14-bit digitizer can resolve 1 count in

- a. 14
- b. 4096
- c. 8192
- d. 16384
- e. 65536

a	b	c	d	e

5. One of the following is **NOT REQUIRED** regarding experimental planning

- a. Statement of objectives
- b. Time
- c. Cost
- d. Manpower
- e. Customer or end user of the data

a	b	c	d	e

6. One of the following is **NOT** true regarding a strain gauge

- a. It is an active device
- b. It is arranged in a Wheatstone bridge circuit
- c. It can be made very small
- d. Its output is strain, i.e., some sort of elongation
- e. Its principle is also applied to certain types of pressure transducers

a	b	c	d	e

7. One of the following is the **MOST APPROPRIATE**. In digital data acquisition, the phenomenon of aliasing is minimized or eliminated by ensuring that

- a. All cables are shielded
- b. Least squares regressions are performed
- c. The data are *sampled* at a frequency of at least twice the expected bandwidth
- d. The data are *filtered* at a frequency of at least twice the expected bandwidth
- e. The different channels are not multiplexed

a	b	c	d	e

8. One of the following is **NOT** a method for reducing noise (in other words, to improve the signal-to-noise ratio)

- a. Use shielded cables
- b. Signal amplification
- c. Hardware filtering
- d. Software filtering
- e. Increased bandwidth

a	b	c	d	e

9. Only one of the following is **TRUE**. If an instrument is described as zeroth order, it

- a. Can be used to measure phase shifts
- b. Can only measure “steady-state” values
- c. Can be used for transient measurements
- d. Can have its sensitivity obtained from a step test
- e. Can have its time constant obtained from a step test

a	b	c	d	e

10. One of the following statements is the **MOST APPROPRIATE** regarding the dynamic performance of a first-order system

- a. Its ability to detect a dynamic signal is determined by $\omega\tau$
- b. Its ability to detect a dynamic signal is determined by ω only
- c. Its ability to detect a dynamic signal is determined by τ only
- d. Its ability to detect a dynamic signal is determined by K and τ
- e. None of the above

a	b	c	d	e

where ω is the angular frequency of the excitation, K is the static sensitivity and τ is the time constant

11. One of the following statements is **INCORRECT** regarding a first-order system

- a. The system can oscillate when subjected to a step input
- b. The time constant can be obtained from the system's step response
- c. The time constant is approximately the time to reach 63% of the final output
- d. The output is always attenuated
- e. The output is always lagged

a	b	c	d	e

12. One of the following sets of parameters is required for modeling a first-order dynamic system

- a. phase lag and amplitude ratio
- b. time constant and amplitude ratio
- c. time constant and sensitivity
- d. dynamic range and sensitivity
- e. dynamic range and signal-to-noise ratio

a	b	c	d	e

13. An instrument, described by a first-order differential equation, is subjected to a field signal containing a broad band of frequencies. One of the following is **TRUE** regarding the output

- a. Harmonics will be excited
- b. Higher frequencies will be attenuated compared to lower frequencies
- c. The signal will be aliased
- d. The noise level will increase
- e. There will be a DC offset unless compensated

a	b	c	d	e

14. When an instrument, described as a first-order system, is subjected to a sinusoidal input, its output can be described by

- a. A DC component and a steady-state component
- b. An oscillatory component and a steady-state component
- c. A transient component and a steady-state component
- d. An imaginary component and a real component
- e. An exponentially damped sinusoid

a	b	c	d	e

15. The time constant of a first-order measurement system is known to be 10 ms. If the device is used to measure an oscillating signal with an angular frequency of 10 rad/s, the phase lag is approximately

- a. 0°
- b. 5.7°
- c. 45°
- d. 84°
- e. 90°

a	b	c	d	e

16. A first-order instrument initially at state (1) reaches a final state (2) when subjected to a step input. The time required to reach 40% of the final state is approximately

- a. 0.5τ
- b. 0.693τ
- c. 0.632τ
- d. 0.707τ
- e. τ

a	b	c	d	e

where τ is the time constant. If needed, $\Gamma = \exp(-t/\tau)$.

17. One of the following is **THE MOST APPROPRIATE** regarding an instrument described by a second-order equation regardless of damping

- a. Harmonics will be excited
- b. Higher frequencies will be attenuated compared to lower frequencies
- c. The signal will be aliased
- d. The noise level will increase
- e. There will be a DC offset unless compensated

a	b	c	d	e

18. One of the following is **TRUE** when a second-order instrument is subjected to a step input

- a. There will be an initial, exponential change in the output
- b. There will be ringing
- c. A heavily damped system will take longer to reach the final state than a lightly damped on
- d. The time constant of the system can be determined by such a test
- e. Harmonics will be excited

a	b	c	d	e

19. One of the following is **FALSE** regarding resonance of an underdamped second-order system

- a. Resonance will not occur if $\zeta > 0.707$
- b. Resonance can damage transducers
- c. Resonance results in $M(\omega) > 1$
- d. Resonance results in considerable phase shift
- e. Resonance can excite subharmonics

a	b	c	d	e

20. Consider a second-order system subjected to a harmonic excitation

$$m \frac{d^2 x}{dt^2} + c \frac{dx}{dt} + kx = F_o \cos \omega t$$

a	b	c	d	e

The m , c and k coefficients are usually associated with

- a. A mass, damper and spring respectively
- b. A moment and two constants
- c. A mass, a deflection and resonance
- d. A mass, a strobe and a time delay
- e. None of the above

21. One of the following statements is **NOT** true about a second-order instrument.

- a. The duration of the transient response is controlled by the $\zeta \omega_n$ term
- b. It is preferable to have the damping ratio in the range of 0.6 – 0.8
- c. Resonance occurs only when the damping ratio is less than one
- d. Ringing occurs when a second-order system is subjected to a sinusoidal input tuned to a specific frequency
- e. Heavily damped systems are sluggish

a	b	c	d	e

22. The transmission band of a second-order instrument is

- a. ± 1 %
- b. ± 3 %
- c. ± 5 %
- d. -0.707% to $+1.414\%$
- e. Depends on the undamped natural frequency

a	b	c	d	e

23. One of the following is **NOT** usually considered a function of signal conditioners

- a. Amplification to boost the signal strength to match digitizer range
- b. Feedback
- c. Convert the signal from one electrical type to another
- d. Filtering to improve signal-to-noise ratio
- e. Linearize the signal (if needed)

a	b	c	d	e

24. One of the following is **NOT** correct regarding digital data acquisition systems

- a. It is usually necessary to amplify the field signal in order to utilize the dynamic range of the analog-to-digital converter
- b. A multiplexed 16 channel, unipolar system will be reduced to 8 channels if operated with bipolar signals
- c. Oversampling can be used in conjunction with an anti-aliasing filter to prevent aliasing
- d. Missing data can be added by post-processing techniques
- e. All analog devices can also be used with digital systems

25. The Home Depot carries the AO Safety reusable ear plug (Model 340-4002) which has a noise reduction rating of 21 dB, in other words, having the earplugs reduces the noise level to 21 dB. This is equivalent to a noise reduction of

- a. 1/21
- b. 1/100
- c. 1/125
- d. 1/1000
- e. 1/2000

a	b	c	d	e

where the noise power without earplug to that with earplug is given by the expression

$$dB = 10 \log_{10} \left(\frac{P_{with}}{P_{without}} \right).$$